TECHNICAL BACKGROUND DOCUMENT
FOR THE REPORT TO CONGRESS
ON REMAINING WASTES
FROM FOSSIL FUEL COMBUSTION:

COST AND ECONOMIC IMPACT ANALYSIS

March 30, 1999

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1.0 INTRODUCTION

This document provides findings of an analysis of cost and economic impacts associated with alternative disposal and management practices for mitigating human health risks from fossil fuel combustion (FFC) wastes. The document is divided into sections covering the following four FFC sectors:

- Comanaged wastes at coal-fired utilities
- Non-utility coal combustion wastes (CCWs)
- Fluidized bed combustion (FBC) wastes
- Oil combustion wastes (OCWs).

It concludes with a section summarizing overall conclusions and presenting industry-level economic impacts. The remainder of this introduction details the approach and methodology used, outlines assumptions, and describes limitations to the analysis.

1.1 APPROACH AND METHODOLOGY

Costs are developed using secondary data on costs for various waste disposal and management practices. Where acceptable data are not available, costs are estimated using cost engineering models and algorithms. Costs are developed in five different forms: capital/one-time costs, recurring capital expenses, annual operating and maintenance costs, closure costs, and annual post-closure costs. These costs are then combined into an annualized before-tax compliance cost to approximate the overall economic impact of complying with various regulatory alternatives and standardizing options that may vary in terms of capital and annual operating requirements. Standard annualizing procedures that incorporate accepted discount rates are used.

Economic impacts are analyzed at two general levels: the firm level and the industry or market level. Each of these requires its own general methodology. For the firm level, impacts are assessed based on a partial budgeting analysis, which includes the use of key financial ratios to assess impacts on costs of production, prices, and financial viability. At the industry or market level, partial market equilibrium analysis is the preferred methodology, with the main objective being to determine general supply and price effects. The partial equilibrium analysis can involve one of three choices: use existing economic models on the energy sector, develop complex new economic models, or conduct a simplified general industry impact analysis.

Because of the changing structure of the power generation industry, lack of appropriate existing major sector models, and extensive resource requirements to develop rigorous models, the approach is a combination of qualitative and simple quantitative analysis. Thus, the industry or market level analysis is restricted to a basic analysis of supply factors (overall effect and incidence of costs).

The partial budgeting analysis at the firm level assumes no price effects. It is assumed that cost pass through will be limited for two general reasons. First, large portions of the electric power generating industry will not be significantly affected and thus opportunities to pass on costs will be limited. Second, the electric utility industry is rapidly changing from a regulated monopolistic regional market structure to an open and competitive national market. Not only will this greatly reduce the potential to pass on increased costs, the complexity and uncertainty during this transition of the market structure makes estimation of possible price adjustments difficult. Also, for non-utility facilities, cost pass through will be limited because only a small share of plants within impacted industries (i.e., those generating FFC waste) will be affected by the alternatives evaluated.

1.2 COST ACCOUNTING AND ECONOMIC IMPACT ASSUMPTIONS

The cost of potential regulations can be viewed in two contexts—economic and financial. The two perspectives consider regulatory costs in two different ways for different purposes. The economic context considers impacts on resource allocation for the economy as a whole, which considers potential effects on supply and demand, shifts to substitute products, and the structure, conduct, and performance of industries. The financial context evaluates private sector effects on plants, firms, and other discrete entities. This study focuses on the financial context (i.e., impacts on plants) and infers general economic effects based on an aggregate level of costs incurred by plants and market conditions that will control how much costs can be shifted to consumers.

Consequently, this study employs data and cost-accounting assumptions consistent with the perspective of plant operators. Thus, impacts look at effects on cost of production and returns. Where discounting of investment or future costs is needed, a general cost of capital discount rate for obtaining financing of 7 percent is assumed, rather than a lower “social” discount rate. While financial impacts are usually assessed on an after-tax basis, this assumption is somewhat complicated for this study, as many “public” plants may be considered “nonprofit” and thus should have a zero tax rate. In this study, all costs are annualized on a before-tax basis. Before-tax compliance costs are used because they represent a resource cost of the alternative management practices considered, measured before any business expense tax deductions available to affected companies. The savings attributable to corporate tax deductions or depreciation on capital expenditures for pollution control equipment are not considered in calculating before-tax costs.

Annual before-tax baseline and compliance costs are estimated for each facility using derived engineering cost estimates and reported and estimated waste quantities. Annual incremental compliance costs are estimated by subtracting the annual baseline cost estimate from the annual compliance cost estimate. In reformulating the costs of compliance, EPA used a discount rate of 7 percent and assumed a 40-year operating life (borrowing period) based on industry data for landfill and impoundment operational periods when annualizing capital, closure, and post-closure costs.

The following formulas were used to calculate the before-tax annualized baseline and compliance costs and estimate annual incremental compliance costs:

Annual Before-Tax Costs =

$$
\begin{aligned}
&(\text{Initial Capital Costs})(CRF_{40}) + \\
&(\text{5-YR Recurring Capital Costs}/1.07^{5})(CRF_{40}) + \\
&(\text{5-YR Recurring Capital Costs}/1.07^{10})(CRF_{40})+ \\
&(\text{5-YR Recurring Capital Costs}/1.07^{15})(CRF_{40})+ \\
&(\text{5-YR Recurring Capital Costs}/1.07^{20})(CRF_{40})+ \\
&(\text{5-YR Recurring Capital Costs}/1.07^{25})(CRF_{40})+ \\
&(\text{5-YR Recurring Capital Costs}/1.07^{30})(CRF_{40})+ \\
&(\text{5-YR Recurring Capital Costs}/1.07^{35})(CRF_{40})+ \\
&(\text{Annual O\&M Costs}) + \\
&(\text{Closure Costs}/1.07^{41})(CRF_{40}) + \\
&(\text{Post Closure O\&M Costs}/CRF_{30})/1.07^{41})(CRF_{40})
\end{aligned}
$$

Where: CRF_n = Capital recovery factor (i.e., the amount of each future annuity payment required to accumulate a given present value) based on a 7-percent real rate of return (I) and a 40-year borrowing period (n) as follows:

$$\frac{(1 + I)^n(I)}{(1 + I)^n-1} = 0.07501 \quad \text{when } n = 40$$

$$= 0.08059 \quad \text{when } n = 30$$

Annual Incremental Compliance Cost = Annual Compliance Cost – Annual Baseline Cost.

1.3 LIMITATIONS OF THE ANALYSIS

Characteristics of the affected industries create conditions that limit the analysis and cause uncertainty in the results. Most of the impacts will be born by the electric power generating industry, an extremely large and complicated industry comprising a diversity of owners with varying objectives and market influence, and a diversity of plants, including fossil fuel and non-fossil energy plants. The industry serves many different markets, which are highly regulated now, but transiting to a less-regulated national market.

The potential impacts on individual plants will be highly varied depending on plant technology, fuel characteristics, waste generation and management practices, and current financial conditions. Many of these conditions cannot be documented with certainty. The combined effects in determining plant responses cannot be well documented either.

2.0 COMANAGED WASTES AT COAL-FIRED UTILITIES

FFC waste generation is divided between two large industrial categories: the electric utility/independent power market and general industries and institutions that operate boilers using fossil fuels. The electric utility and power producers use a much greater share of fossil fuel energy and have a greater and more concentrated generation of FFC wastes. Comanaged wastes generated by coal-fired electric utilities (hereinafter referred to as "comanaged wastes") account for almost all of the affected FFC waste. This section describes the potential compliance costs and economic impacts of alternative management practices for comanaged wastes.

2.1 DATA SOURCES

The data sources fall into two general groups: data sources for estimating costs and data sources for profiling the industry and assessing economic impacts. The sources for estimating costs include those used to profile and develop the use of alternative management practices, sources on waste quantities and characteristics, and sources for unit cost estimates or cost estimating models. Major sources follow:

- The Electric Power Research Institute (EPRI) comanagement survey (EPRI, 1997a)
- The Department of Energy (DOE) Energy Information Administration (EIA) 767 database (included in the Edison Electric Institute Power Statistics Database [EEI, 1994])
- R.S. Means, *Environmental Remediation Cost Data* (R.S Means, 1998a, 1998b)
- R.S. Means, *Site Work and Landscape Cost Data* (R.S. Means, 1997)
- The EPRI study of mill rejects management (EPRI, 1999).

The data sources for profiling the industry and assessing economic impacts are trade association reports, general industry studies, and industry data series and reports from government sources such as the Department of Energy and the Department of Commerce. Major sources follow:

- Department of Energy, Energy Information Administration (EIA, 1995a, 1995b, 1995c, 1995d, 1995e, 1996a, 1996b, 1996c, 1996d, 1996e, 1997a, 1997b, 1997c, and 1997d)
- Department of Commerce, Bureau of the Census (DOC, 1992, 1994, 1995a, 1995b, and 1995c)
- Public Utilities Reports, Inc. (Morin, 1994; PUR, 1994).

2.2 DESIGN, OPERATION, AND COST-ESTIMATING ASSUMPTIONS

Costs are estimated for baseline (current) and alternative (compliance) risk mitigation management practices for comanaged wastes generally and for mill rejects generated by coal-fired utility plants. The risk mitigation management practices discussed in this section reflect the range of management practices currently employed and the alternative management practices that the Agency believes can be employed to mitigate potential human health risks. The following paragraphs reflect the critical design, operating, and cost assumptions used in developing these cost estimates.

2.2.1 Waste Management Unit Size Assumptions

Baseline and compliance cost estimates were developed using unit cost data from engineering cost literature and vendor quotation for three different landfill and impoundment sizes representing the range of comanaged waste or mill reject management unit capacities. Table 2-1 presents the design parameters assumed for the three different management unit sizes. Of note are the large impoundment areas. Liner construction accounts for most of the estimated cost. These construction costs are driven by the area to be covered, which makes the incremental unit costs for impoundments higher than landfills because impoundments cannot be constructed aboveground in a pile design similar to a landfill.

2.2.2 Population and Waste Generation Assumptions

Capital, operating, closure, and post-closure cost estimates for each design were developed, discounted into 1998 dollars, and annualized over a 40-year operating life (based on industry unit operation data) assuming a 7-percent real discount rate (based on OMB guidance). The three annualized cost estimates were curve-fitted using regression analysis into a single cost equation. Annualized costs were then estimated as a function of either the comanaged waste or mill reject generation rate on a plant- specific basis. Total industry costs were derived by summing the plant-specific cost estimates derived for the 353 identified coal-fired plants identified in the EEI database (EEI, 1994) that have electrical generating capacities of at least 10 megawatt (MW).

Cost estimates were derived on a plant-specific basis to minimize uncertainty associated with the quantity of waste generated. Table 2-2 summarizes the extent of reported (known) and unreported (estimated) ash quantities reflected within the cost estimate for the 353 identified coal-fired plants. Out of the population of 353 coal-fired plants, 256 (73 percent) reported the quantity of large-volume CCW they generated in 1993. Since coal usage data were available for all 353 plants, quantities for nonreporting plants were

Table 2-1. Design Parameters Assumed for Small, Medium, and Large Landfills and Impoundments

Parameter		Comanaged Waste Landfill	Comanaged Waste Impoundment	Mill Reject Landfill
Sizes	small	9,650	7,220	50
(tons/year)	medium	96,500[a]	72,200[a]	1,700[a]
	large	965,000	722,000	9,700
Depth		Pile Design		Pile Design
(feet)	small	1.0	10.0	1.0
	medium	1.0	20.0	1.0
	large	3.0	20.0	1.0
		Combination Fill Design		Combination Fill Design
	small	10.0		5.0
	medium	31.0		10.0
	large	58.6		25.0
	reported range[b]	0.3 – 150	1.0 – 200	
	central tendency[c]	31	12	
	high end[c]	110	125	
Height		Pile Design		Pile Design
(feet)	small	25.0	0	15.0
	medium	30.5	0	25.0
	large	79.4	0	25.0
		Combination Fill Design		Combination Fill Design
	small	14.8		7.4
	medium	40.5		12.6
	large	79.4		32.3
Area		Pile Design		Pile Design
(acres)	small	13.5	21.4	0.2
	medium	239.1	106.3	2.9
	large	479.2	1,023	13.5
		Combination Fill Design		Combination Fill Design
	small	13.0		0.2
	medium	44.1		2.5
	large	228		6.4
	reported range[b]	2.6 – 900	5 – 1,500	
	central tendency[c]	66	90	
	high end[c]	328	412	

[a] Median total ash and flue gas desulfurization (FGD) sludge quantity reported in EEI, 1994. The mill reject median value is calculated using reported coal usage data in the database (EEI, 1994) and an EPRI mill reject average generation rate factor as a function of coal usage
[b] EPRI, 1997a
[c] EPA, 1998a

estimated based on the calculated average waste generation rate per ton of coal used by reporting plants. These 353 coal-fired plants generate approximately 88.1-million tons of waste annually. Of this amount, approximately 69.7-million tons are bottom ash and fly ash and approximately 18.7-million tons are flue

Table 2-2. Waste Quantities Used in Cost Analysis (million tons, 1993)

Quantity Reporting	Number of Plants	Ash Quantity (million tons)	FGD Quantity (million tons)	Total Quantity (million tons)
Reported Ash Reported FGD Waste	256	56.11	11.16	67.27
Reported Ash Unreported FGD Waste	40	10.59	6.96[b]	17.55
Unreported Ash	4	1.47[a]	0	1.47
Unreported Ash Unreported FGD Waste	53	1.23[a]	0.60[b]	1.83
Total	**353**	**69.40**	**18.72**	**88.12**

[a] Quantities estimated based on reported coal usage and mean ash generation ratio for those plants that reported ash quantities (0.126 tons of ash/ton of coal used)
[b] Quantities estimated based on reported coal usage and mean FGD sludge generation ratio for those plants that reported ash quantities (0.075 tons of FGD sludge/ton of coal used)
Source: EEI, 1994

gas desulfurization (FGD) waste. These totals, however, reflect all large-volume waste quantities combined, whether these wastes are comanaged with low-volume wastes or not.

Plant-specific data on comanagement of low-volume wastes with large-volume wastes are not available. EPRI's comanagement survey data indicate that not all large-volume utility CCWs are comanaged. Overall, approximately 80 percent of the 259 active facilities surveyed comanage at least one low-volume waste. By management unit type, comanagement occurs in 91 percent of the surface impoundments, 70 percent of the landfills, and 75 percent of the minefills (EPRI, 1997b). Table 2-3 presents large-volume waste quantities by how they were managed in 1993. The above comanagement percentages for surface impoundments and landfills are applied to the totals to derive a total comanaged waste quantity estimate.

Based on data from the EEI database, 34.3-million tons of large-volume waste are disposed in a landfill, 28.3-million tons are disposed in an impoundment, 3.1-million tons are stored onsite, 4.4-million tons involve payment for offsite disposal or use (this quantity captures minefill disposal), and 10-million tons are sold for beneficial uses. For the cost analysis, stored quantities and quantities for which the plant paid an entity to manage the waste offsite are assumed to be disposed in a landfill. Minefilled quantities likely are included in the paid quantity total and thus are assigned a landfill cost. Comanaged waste quantities were estimated for nonreporting plants based on the percentage reported landfilled (53 percent for fly ash and bottom ash and 59 percent for FGD waste) and impounded (46 percent for fly ash and

Table 2-3. Waste Quantities by Management Practice Used in Cost Analysis (million tons, 1993)

Plant Category	Landfill	Impoundment	Stored	Paid	Sold
Reported Ash (number of plants)	23.14 (131 plants)	20.42 (157 plants)	3.45 (71 plants)	10.76 (169 plants)	8.92 (88 plants)
Estimated Ash (number of plants)[a]	1.43 (57 plants)	1.20 (57 plants)	--	--	--
Reported FGD Waste (number of plants)	5.27 (35 plants)	3.62 (22 plants)	0.95 (7 plants)	0.16 (5 plants)	1.16 (7 plants)
Estimated FGD Waste (number of plants)[b]	4.46 (39 plants)	3.10 (39 plants)	--	--	--
Totals	34.30	28.34	4.40	10.92	10.08
Comanaged Totals[c]	24.01	25.79	3.08	7.64	--

[a] Quantities estimated based on reported coal usage and mean ash generation ratio for those plants that reported ash quantities (0.126 tons of ash/ton of coal used)
[b] Quantities estimated based on reported coal usage and mean FGD sludge generation ratio for those plants that reported ash quantities (0.075 tons of FGD sludge/ton of coal used)
[c] EPRI comanagement survey data indicate that 70 percent of landfill quantity is comanaged and 91 percent of impounded quantity is comanaged. Assumed that stored and paid quantities are landfilled in cost estimate. No costs are assigned to sold quantities
-- = not estimated
Source: EEI, 1994

bottom ash and 41 percent for FGD waste) by reporting plants. Overall, this analysis assumes that 49.6-million tons are landfilled, 28.3-million tons are impounded, and 10-million tons are sold. No costs are assigned to quantities sold to other entities assuming they have a beneficial use value. Thus, after applying the 70 percent and 91 percent comanagement percentages for landfills and impoundments, respectively, the total quantity of comanaged waste potentially affected by the waste management alternatives is 60.5-million tons (34.7-million tons are landfilled and 25.8-million tons are impounded).

Total mill reject generation is estimated to range between 31,000 and 970,000 tons annually, with an expected value of approximately 440,000 tons annually assuming all coal-fired boilers generate mill rejects. No data are available on coal mill reject (pyrite) waste quantities from coal-fired utilities on a facility-specific basis. EPRI conducted a study of 16 coal plants (EPRI, 1999). At these plants, between 0.15 lbs/hr and 2,800 lbs/hr, with an average of 350 lbs/hr, of pyrite wastes are generated. Using these generation rates as a guideline, three pyrite generation rate scenarios (low, medium, and high) were estimated. In the low scenario, pyrite is assumed to be generated at a rate of 0.005 percent of the coal usage rate. This assumption results in an average generation rate of 4 lbs/hr when applied to the total population of coal-fired plants and generation rates of 0.15 lbs/hr are predicted in the lower tail of the distribution. In the medium scenario, pyrite is assumed to be generated at a rate of 0.09 percent of the coal usage rate. This assumption results in an average generation rate of 363 lbs/hr for the total population of coal-fired plants. Generation rates of 350 lbs/hr are predicted in the middle of the distribution. In the high scenario, pyrite is assumed to be generated at a rate of 0.2 percent of the coal usage rate. This assumption results in an average generation rate of 807 lbs/hr for the total population of coal-fired plants. Generation rates of 2,800 lbs/hr are predicted in the upper tail of the distribution.

EPRI estimates that only 75 percent of the coal-fired utility plants generate mill rejects and comanage them with ash (EPRI, 1999). For the cost analysis, it is assumed that 75 percent of the coal-fired utility plants generate mill rejects at an expected annual generation rate of 330,000 tons, with a range of between 23,000 and 727,000 tons. However, 62 of the 353 plants (18 percent) are located in a western U.S. state (i.e., all states including and to the west of a line extending from North Dakota south to New Mexico plus Minnesota), which are assumed to be using western coal. Mill rejects from western coal do not contain pyrite; therefore, these plants do not need to modify their mill reject management practices.

2.2.3 Comanaged Waste Management Unit Design Assumptions

For the baseline cost estimate, the Agency assumes there are three different liner designs for both comanaged waste landfills and impoundments. These designs are unlined, clay-lined, and composite-lined management units. EPRI comanagement survey data indicate that current landfill designs include 51.1 percent that are unlined, 28.7 percent that are clay-lined, and 20.2 percent that are either single-synthetic, composite, or double-synthetic lined. Current impoundment designs include 73.2 percent that are unlined, 21.4 percent that are clay-lined, and 5.4 percent that are either single-synthetic, composite, or double-synthetic lined. The specific landfill and impoundment capital and operation and maintenance components included in the cost estimates are identified in Table 2-4. In terms of spacial arrangement, cost estimates were developed for both combination fill (below and above ground) and pile design (above-ground) landfills. For the risk mitigation alternative, the Agency assumes that generators who comanage waste will construct composite-lined landfills and impoundments.

2.2.4 Mill Rejects Management Unit Design Assumptions

For baseline mill reject management methods, costs are a subset of the baseline cost estimate for comanaged ash landfills and impoundments. In the cost estimates presented below, mill reject baseline costs are included with the comanaged coal ash baseline cost estimate.

Table 2-4. Cost Components Included in Landfill and Impoundment Designs

	Landfill			Impoundment		
Component	**Unlined**	**Clay-Lined**	**Composite-Lined**	**Unlined**	**Clay-Lined**	**Composite-Lined**
Initial Capital Costs						
Land Purchase	Yes	Yes	Yes	Yes	Yes	Yes
Site Development	Yes	Yes	Yes	Yes	Yes	Yes
Excavation	Yes	Yes	Yes	Yes	Yes	Yes
Filter Fabric	No	Yes	Yes	No	No	Yes
1' Sand	No	Yes	Yes	No	No	Yes
2' Clay Liner	No	Yes	Yes	No	Yes	Yes
Synthetic (HDPE) Liner	No	No	Yes	No	No	Yes
Leachate Collection	No	Yes	Yes	No	No	Yes
Ground-Water Wells	No	Yes	Yes	No	Yes	Yes
Indirect Capital Costs	Yes	Yes	Yes	Yes	Yes	Yes
Recurring Capital Costs (5 years)						
Heavy Equipment (dump truck, bulldozer, sheepsfoot roller, water truck)	Yes	Yes	Yes	--	--	--
Indirect Capital Costs	Yes	Yes	Yes	–	--	--
Annual Operation and Maintenance Costs	Yes	Yes	Yes	--	--	--
Heavy Equipment Operation	No	Yes	Yes	No	Yes	Yes
Environmental Monitoring	No	Yes	Yes	No	No	Yes
Leachate Collection and Treatment						
Closure Costs						
6" Topsoil and Vegetation	Yes	Yes	Yes	Yes	Yes	Yes
1.5' Soil	Yes	No	No	Yes	No	No
Filter Fabric	No	Yes	Yes	No	Yes	Yes
1.5' Sand	No	Yes	Yes	No	Yes	Yes
2' Clay	No	Yes	Yes	No	Yes	Yes
Synthetic (HDPE) Liner	No	No	Yes	No	No	Yes
Added Fill to Achieve Slope	--	--	--	No	Yes	Yes
Cover Drainage System	No	Yes	Yes	No	Yes	Yes
Indirect Closure Costs	Yes	Yes	Yes	Yes	Yes	Yes
Annual Post-Closure Costs						
Environmental Monitoring	No	Yes	Yes	No	Yes	Yes
Landscape Maintenance	Yes	Yes	Yes	Yes	Yes	Yes
Slope Maintenance	Yes	Yes	Yes	Yes	Yes	Yes
Inspection	Yes	Yes	Yes	Yes	Yes	Yes
Administration	Yes	Yes	Yes	Yes	Yes	Yes

-- = not applicable

For the risk mitigation alternative, the Agency assumes that generators of mill rejects will either construct composite-lined pile or combination fill design landfills or coburn mill rejects, depending on which method is most economical. In all cases, a composite-lined pile design was the most economical choice. For landfilling of mill rejects blended with lime, capital and operating components include those items listed in Table 2-4 plus lime purchase and mixing operation and maintenance (O&M) costs. Engineering cost assumptions for the mill reject coburning include construction and operation of a mill reject hammer mill and conveyance system. Capital cost components include a conveyance system from the existing mill reject collection bin to a hammer mill, hammer mill (replaced every 10 years), storage bin, hopper, vibratory screen, dust collection, access road, site grading, concrete slab, structural steel, electrical installation, and a conveyance system to the coal feed storage silo. Other costs include permitting, insurance and bonding, construction management, engineering design, overhead, profit, and contingencies. Operation and maintenance cost components include electricity, operating and maintenance labor, maintenance materials, and contingencies. Economies of scale are not incorporated into the estimate for those plants that can share disposal facilities, thus reducing their costs.

In the risk mitigation alternative, the Agency assumes that if a plant is located in a western U.S. state (i.e., all states including and to the west of a line extending from North Dakota south to New Mexico plus Minnesota), it uses western coal. Mill rejects from western coal do not contain pyrite. Therefore, plants using western coal would not need to modify their mill reject management practices. Such plants are assigned a $1,000 annual cost to demonstrate that their mill rejects contain no pyrite.

2.3 ANNUALIZED BASELINE, COMPLIANCE, AND INCREMENTAL COSTS

Risk mitigation costs have been estimated for comanaged waste and mill rejects. Key variables in estimating incremental compliance cost are the number of affected plants, current management practices, estimated waste generation quantities, and costs of key components (e.g., liners). The annual incremental before-tax compliance costs for comanaged waste are estimated to be $860 million per year for 52.1-million tons ($16.51/ton), using the most likely values for all the input variables. The potential range of annual incremental compliance cost is from $430 million for 45.3-million tons ($9.49/ton) to $1,330 million for 59.7-million tons ($22.28/ton), assuming all key variables combine at either the high or low end. It is EPA's judgment, however, that the likely range would be $800 million to $900 million per year based on reasonable estimates of uncertainty in the input variables and the low probability that all variables would combine at either their high- or low-end values.

The incremental costs for mill rejects (alone) are estimated to be $20 million per year. The potential range of annual incremental costs for mill rejects alone is from less than $1 million to $50 million, accounting for uncertainty in estimated quantities and unit costs.

2.4 IMPACTS AS A FUNCTION OF PLANT SIZE

This section provides estimates of the potential economic impacts on facilities, businesses, and industry of alternative management practices. The estimated waste quantities include 66.2-million comanaged tons affected (75 percent) out of 88.1-million total tons of large-volume waste from coal-fired electric utilities. The alternative management practices are expected to affect as many as 353 coal-fired electric utility plants owned by about 220 entities, including private- and investor-owned companies, small and large local governments, and the federal government. Because of data constraints on ownership and financial information, the impacts on individual plants can be assessed only on a general basis.

The electric utility segment is characterized by rather homogeneous operations for which fossil fuel, when used, is the single largest production input. To indicate the general magnitude of impacts on such plants, general model or representative financial pro forma statements have been developed that will indicate the general level of economic conditions and impacts common types of plants and plant operators should experience.

The partial budgeting analysis, using model plants, is limited to ratio analysis of general operating conditions (i.e., effect on costs and net income). Pro forma operating and financial profiles (Table 2-5) present both the baseline economic parameters for representative plants as well as compliance costs. The economic parameters are limited to income statement measures to assess the general effect on an operation’s viability. Capital budget or balance sheet impacts are not considered.

The preliminary impacts analysis indicates the management of comanaged waste under expected management options should not cause significant impacts on the financial viability of coal-fired plants. This appears true even for plants that are switching from the worst case unlined landfill or impoundment baseline management method to a composite-lined landfill or impoundment. For example, a large investor-owned utility (IOU) coal-fired plant with more than 1,000 megawatts of generating capacity and generating 6-billion kWh per year is estimated to be able to mitigate risks from comanaged waste for about $6.16 million per year or about $15.81 per ton of large-volume waste. Based on typical annual revenues and cost, compliance costs would increase overall costs by 1.5 percent of revenues. Without any price adjustments, net income before taxes for a typical investor-owned plant would be reduced from about 13 percent to 11.5 percent and remain at more than $45 million per year (Table 2-5).

Table 2-5. Pro Forma Financial Analysis of Economic Impacts for Comanaged Wastes

	Units	LARGE COAL PLANT Investor-Owned Utility			MEDIUM COAL PLANT Investor-Owned Utility			SMALL COAL PLANT Publicly Owned Utility		
		No.	Percent	Notes	No.	Percent	Notes	No.	Percent	Notes
PLANT CHARACTERISTICS										
Plant Generating Capacity	MW	1,105		e	368		e	184		e
Fuel Consumption: Coal	1,000 s.t.	3,000		e	1,000		e	500		e
Sales of Electricity	Mil. kwh	6,000			2,000		e	1,000		
Price of Electricity	$/kwh	0.071		a	0.071		a	0.06		a
Revenues from Electricity	$1,000	426,000	100.0%	d	142,000	100.0%	d	60,000	100.0%	d
COSTS										
Energy Costs	$1,000	213,000	50.0%	b	71,000	50.0%	b	33,000	55.0%	f
Operating Expenses	$1,000	119,280	28.0%	d	39,800	28.0%	d	18,000	30.0%	d
Interest Expenses	$1,000	38,340	9.0%	g	12,800	9.0%	g	3,600	6.0%	f
Total Baseline Costs	$1,000	370,620	87.0%	d	123,600	87.0%	d	54,600	91.0%	d
NET INCOME: Baseline Before Tax	$1,000	55,380	***13.0%***	c	18,400	***13.0%***	c	5,400	***9.0%***	f
INCREMENTAL COSTS										
Expected	$1,000	6,165	1.5%		2,197	1.6%		1,285	2.1%	
Upper-Bound	$1,000	7,702	1.8%		2,773	1.9%		1,576	2.6%	
NET INCOME										
Post-Compliance – Expected	$1,000	49,215	***11.5%***		16,203	***11.4%***		4,115	***6.9%***	
Post-Compliance – Upper-Bound	$1,000	47,678	***11.2%***		15,627	***11.1%***		3,824	***6.4%***	
COMPLIANCE ASSUMPTIONS										
Waste Generated	1,000 tons	390		h	120		h	50		h
Compliance Option		Lined LF/SI			Lined LF/SI			Lined LF/SI		
Unit Cost of Compliance: Expected	$/ton	15.81			18.31			25.70		
Unit Cost of Compliance: Upper-Bound	$/ton	19.75			23.11			31.52		

a. EIA, 1996f
b. Average rate based on sample of investor-owned utilities
c. Median net income after tax (8 percent) from Fortune 1,000 utilities (*Fortune*, April 27, 1998) and assuming average tax rate of 40 percent
d. Computed based on other assumptions
e. EIA, 1995a. For coal, 301,098 megawatts of generator capacity produced 1,635-billion kWh and consumed 817-million short tons of coal in the United States
f. Ratio analysis of sample utilities from EIA, 1995b
g. Ratio analysis of sample utilities from EIA, 1995d
Unit Conversions: coal unit productivity = 5.430126-million kWh per megawatt capacity; coal fuel efficiency = 2001.224-million kWh per million short tons of coal
h. Includes coal ash and FGD sludge

Financial impacts on a medium-sized coal plant operated by an IOU suggest it should remain financially viable. Costs would increase by about 1.6 to 1.9 percent of revenues, with profitability (before tax) at between 11.1 and 11.4 percent of revenue and net income levels after compliance of more than $15 million per year. Annual incremental compliance costs are estimated at between $18.31 and $23.11 per ton, or about $2.2 to $2.8 million per year (Table 2-5).

Because of higher unit compliance costs and lower net income margins, smaller publicly owned coal-fired plants would incur relatively higher impacts, but still be financially viable even under a worst case unlined baseline management situation. For example, an average small publicly owned plant with about 180 MW of capacity and generating 1-billion kWh per year is estimated to be able to mitigate risks from comanaged waste disposal for about $1.3 to $1.6 million per year, or about $25.70 to $31.52 per ton. Based on typical revenues and costs, compliance costs for a small coal-fired utility would increase overall costs about 2.1 to 2.6 percent. This would reduce net income, without price adjustments, from about 9 percent to 6.4 to 6.9 percent of revenue (Table 2-5).

Therefore, based on a cross-section of representative coal-fired plants, impacts at the plant level for mitigating risks from comanaged waste are expected to be insignificant in terms of financially threatening normal operations. Generally, both investor and publicly owned plants exhibit net returns of 7 to 13 percent of revenue. Costs for any such operations on average are not expected to increase more than 2.5 percent of revenues, thus allowing net income to remain positive.

Again, the plant-level findings presented above are subject to limitations. The primary limitation is they do not reflect the great variation that exists between plants in terms of efficiency, electricity pricing, management quality, and age and level of generating technology. While the models do provide a reasonable representation of the norm, substantial variation can occur both above and below the figures shown. Also, this analysis is restricted to operations exhibiting positive returns in the baseline; i.e., plants that are financially viable in the baseline. Marginal operations can appear to have significant financial impacts, but these should be attributed to poor management or inefficient operations and not alternative management.

3.0 NON-UTILITY COAL COMBUSTION WASTE

As noted earlier, FFC waste is generated in two large industrial categories: the electric utility/independent power market and general industries and institutions that operate boilers using fossil fuels. The second category includes generators of non-utility coal combustion wastes (CCWs). This section provides findings of an analysis of cost and economic impacts associated with alternative disposal and management practices for mitigating human health risks from non-utility CCWs.

3.1 DATA SOURCES

The data sources fall into two general groups: data sources for estimating costs and data sources for profiling the industry and assessing economic impacts. The sources for estimating costs include those used to profile and develop the use of alternative management practices, sources on waste quantities and characteristics, and sources for unit cost estimates or cost estimating models. Major sources follow:

- 1990 National Interim Emission Inventory (EPA, 1990)
- R.S. Means, *Environmental Remediation Cost Data*, (R.S. Means, 1998a and 1998b)
- R.S. Means, *Site Work and Landscape Cost Data* (R.S. Means, 1997).

The data sources for profiling the industry and assessing economic impacts are trade association reports, general industry studies, and industry data series and reports from government sources such as the Department of Energy and the Department of Commerce. Major sources follow:

- Department of Energy, Energy Information Administration (EIA, 1995a, 1995b, 1995c, 1995d, 1995e, 1996a, 1996b, 1996c, 1996d, 1996e, 1997a, 1997b, 1997c, and 1997d)

- Department of Commerce, Bureau of the Census (DOC, 1992, 1994, 1995a, 1995b, and 1995c).

3.2 DESIGN, OPERATION, AND COST-ESTIMATING ASSUMPTIONS

Costs are estimated for baseline (current) and alternative (compliance) risk mitigation management practices for non-utility CCWs. The risk mitigation management practices discussed in this section reflect the range of management practices that are currently employed and the alternative management practices that the Agency believes can be employed to mitigate potential human health risks. The following paragraphs reflect the critical design, operating, and cost assumptions used in developing these cost estimates.

3.2.1 Waste Management Unit Size Assumptions

Baseline and compliance cost estimates were developed using unit cost data from engineering cost literature and vendor quotation for three different landfill sizes representing the range of potential non-utility ash management unit capacities. Table 3-1 presents the design parameters assumed for the three different management unit sizes.

Table 3-1. Design Parameters Assumed for Small, Medium, and Large Non-Utility CCW Landfills

Parameter		Non-Utility CCW Landfill
Sizes (tons/year)	small	150
	medium	5,000[a]
	large	15,000
Depth (feet)		Pile Design
	small	1.0
	medium	1.0
	large	1.0
		Combination Fill Design
	small	3.3
	medium	17.4
	large	43.6
	central tendency[b]	17.4
	high end[b]	43.6
Height (feet)		Pile Design
	small	15.0
	medium	25.0
	large	25.0
		Combination Fill Design
	small	4.3
	medium	22.2
	large	28.1
Area (acres)		Pile Design
	small	0.4
	medium	5.6
	large	15.7
		Combination Fill Design
	small	0.5
	medium	3.5
	large	6.5
	central tendency[b]	1.9
	high end[b]	8.5

[a] Median non-utility ash quantity based on calculated data derived from EPA, 1990
[b] EPA, 1998b

3.2.2 Population and Waste Generation Assumptions

Capital, operating, closure, and post-closure cost estimates for each design were developed, discounted into 1998 dollars, and annualized over a 40-year operating life (based on industry unit operation data) assuming a 7-percent real discount rate (based on OMB guidance). The three annualized cost estimates were curve-fitted using regression analysis into a single cost equation. Annualized costs then were estimated as a function of non-utility ash generation rate on a plant-specific basis. Total industry costs were derived by summing the plant-specific cost estimates derived for the 958 non-utility facilities identified in the National Interim Emissions Inventory (EPA, 1990).

Total annual non-utility CCW generated is estimated to be approximately 5-million tons. For non-utility facilities, waste management data are not reported in the Inventory (EPA, 1990). Based on data compiled on non-utilities that burn FFC wastes and use onsite disposal, landfills were found to be the waste management practice used by most industrial facilities (EPA, 1997). Site-specific data regarding disposal methods were collected from facilities from six states: New York, Illinois, Virginia, North Carolina, Wisconsin, and Pennsylvania. Information collected from Illinois, however, was not sufficient to determine FFC management practices at individual facilities. Based on these data, 78 percent of the 50 facilities included in this study used onsite or captive landfilling. The remaining 22 percent of the facilities use offsite landfill, land application, onsite surface impoundments, storage, or some other unspecified methods of management.

The database (EPA, 1990) was used to estimate non-utility CCW generation quantities and compiled to provide a consistent National Emission Inventory for use in regional modeling and emission trends analysis. Based on the 1985 National Acid Precipitation Assessment Program (NAPAP) inventory, the database includes information on all major stationary sources of criteria pollutants permitted under the Clean Air Act (CAA) and provides annual coal usage quantities per year and percent ash content, which were used to predict total ash generation for all 958 facilities. The database is limited to only the largest criteria pollutant emissions sources in the country. It does not include several thousand boilers that fall below emissions thresholds that qualify the facilities as major sources under the CAA. Typically, point sources emitting less than 100 tons per year of criteria pollutants are not included.

Waste generation quantities were estimated for the non-utility facilities by multiplying their reported ash content by their coal usage as reported in the database. Waste generation was estimated for facilities that did not report coal usage or ash content by assigning the average of the waste quantity, on a per-facility basis, from each standard industrial classification (SIC) code to the nonreporting facility(ies) within each SIC code.

Waste generation quantities are overestimated because the collection efficiencies of air pollution control devices have not been taken into consideration. The intention of the database is to track air emissions; therefore, it does not track waste management information. Also, the database tracks only major emission sources and does not capture the smaller non-utility facility population. The major emission sources likely generate almost all of the non-utility CCW. The smaller entities are likely to be commercial/institutional boilers rather than industrial boilers.

3.2.3 Waste Management Unit Design Assumptions

For the baseline cost estimate, the Agency assumes that non-utility CCW landfills are unlined. The specific landfill capital and operation and maintenance components included in the cost estimates are identified in Table 3-2. In terms of spatial arrangement, cost estimates were developed for both combination fill (below and above ground) and pile design (above-ground) landfills. For compliance with the new regulation, the Agency assumes that generators who dispose non-utility ash will construct composite-lined landfills onsite or transport them offsite to a commercial Subtitle D landfill. The most economical method is assigned to each plant depending upon its annual non-utility ash generation rate.

3.3 ANNUALIZED BASELINE, COMPLIANCE, AND INCREMENTAL COSTS

A summary of the annual incremental before-tax compliance costs for non-utility CCW is presented in Table 3-3. Incremental compliance costs for non-utility CCW are estimated to be $103 million per year for 5-million tons ($20.60/ton).

3.4 IMPACTS AS A FUNCTION OF PLANT SIZE

This section provides estimates of potential economic impacts on facilities, businesses, and industry of alternative management practices. The estimated waste quantities include 5-million tons of non-utility CCW from industrial/institutional facilities. A wide range of facilities and entities would be affected, including about 950 industrial/institutional facilities with coal-fired boilers owned by an unknown number of companies or other entities. Because of data constraints on ownership and financial information, the impacts on individual plants can be assessed on a general basis only.

Table 3-2. Cost Components Included in Landfill Design

Component	Landfill	
	Unlined	Composite-Lined
Initial Capital Costs		
Land Purchase	Yes	Yes
Site Development	Yes	Yes
Excavation	Yes	Yes
Filter Fabric	No	Yes
1' Sand	No	Yes
2' Clay Liner	No	Yes
Synthetic (HDPE) Liner	No	Yes
Leachate Collection	No	Yes
Ground-Water Wells	No	Yes
Indirect Capital Costs	Yes	Yes
Recurring Capital Costs (5 years)		
Heavy Equipment (dump truck, bulldozer, sheepsfoot roller, water truck)	Yes	Yes
Indirect Capital Costs	Yes	Yes
Annual O&M Costs		
Heavy Equipment Operation	Yes	Yes
Environmental Monitoring	No	Yes
Leachate Collection and Treatment	No	Yes
Closure Costs		
6" Topsoil and Vegetation	Yes	Yes
1.5' Soil	Yes	No
Filter Fabric	No	Yes
1.5' Sand	No	Yes
2' Clay	No	Yes
Synthetic (HDPE) Liner	No	Yes
Added Fill to Achieve Slope	--	--
Cover Drainage System	No	Yes
Indirect Closure Costs	Yes	Yes
Annual Post-Closure Costs		
Environmental Monitoring	No	Yes
Landscape Maintenance	Yes	Yes
Slope Maintenance	Yes	Yes
Inspection	Yes	Yes
Administration	Yes	Yes

-- = not applicable

In general, the affected facilities represent a small share of an industry or economic sector, and fossil fuel use and costs are a relatively small part of production inputs and costs. The most common types of facilities affected include pulp and paper mills, food processing facilities, chemical plants, and educational institutions/universities.

Table 3-3. Non-Utility Facility Risk Mitigation Cost Estimates for Non-Utility CCW (1998 $, 1993 tons)

SIC	Number of Facilities	Quantity (million tons)	Baseline Cost (Unlined Landfill, million $/yr)	Compliance Cost (Composite-Lined Landfill, million $/yr)	Incremental
20	98	0.452	$7.039	$16.733	$9.694
21	11	0.041	$0.652	$1.571	$0.919
22	59	0.121	$2.077	$5.228	$3.150
25	35	0.003	$0.170	$0.255	$0.085
26	140	1.255	$18.750	$43.175	$24.425
28	114	1.252	$18.533	$42.283	$23.750
29	12	0.026	$0.437	$1.123	$0.686
30	21	0.065	$1.059	$2.582	$1.523
32	17	0.059	$0.939	$2.203	$1.264
33	44	0.193	$3.010	$7.088	$4.078
34	21	0.047	$0.801	$2.009	$1.209
35	26	0.062	$1.044	$2.636	$1.593
36	15	0.037	$0.615	$1.522	$0.908
37	61	0.130	$2.225	$5.653	$3.427
49	44	0.676	$9.889	$22.238	$12.348
80	58	0.079	$1.485	$4.013	$2.528
82	77	0.219	$3.601	$8.916	$5.315
92	26	0.026	$0.535	$1.446	$0.910
97	17	0.025	$0.449	$1.166	$0.718
Other SICs	53	0.214	$3.363	$7.850	$4.487
Unknown SICs	9	0.008	$0.169	$0.485	$0.315
Total	**958**	**4.986**	**$76.840 ($15.41/ton)**	**$180.172 ($36.14/ton)**	**$103.331 ($20.72/ton)**

Note: Individual values may not sum to total due to rounding.

Examples of the order of magnitude of facility level impacts are provided below by comparing average compliance costs with representative sales for general sizes and categories of facilities. For example, about 98 food processing facilities are expected to incur incremental annualized compliance costs of $9.7 million or about $100,000 per facility per year from alternative management practices. In comparison, in 1992 the Bureau of the Census reported there were about 15,000 establishments engaged in food processing (SIC

20) with annual value of shipments of $281 billion or $18.7 million per facility. Thus, for this industry, less than 1 percent of the facilities would incur any impacts. Furthermore, if the affected facilities reflect the average industry facility in 1992, compliance costs would equal about 0.6 percent of annual shipment or sales. Most affected facilities, however, are expected to be relatively large, as only large facilities can usually justify captive coal-fired boiler operations. For comparative purposes, in 1992 the food processing industry contained 2,788 facilities employing 100 or more employees. These larger facilities had combined-value shipments of $225 billion or $81 million per facility. Thus, if the 98 affected facilities were all large, still only 1 in 30 would be affected and the incremental compliance costs would be 0.12 percent of annual sales. Similar comparisons are shown in Table 3-4 for selected industries, which show facility level impacts for industrial/institutional facilities should not be significant. The sectors presented include food processing, pulp and paper, chemical manufacturing, primary metals, and transportation equipment. Together, these five industries account for about 80 percent of non-utility CCW generation (EPA, 1990).

Table 3-4. Facility-Level Economic Impacts (Non-Utility CCWs)

Sector	Number of Affected Facilities	Facility Size	Average Facility Sales ($million/yr)	Average Facility Incremental Compliance Cost ($million/yr)	Compliance Cost as a Percentage of Sales
Food Processing	98	Average Large	$19 $81	$0.10 $0.10	0.5% 0.1%
Pulp and Paper	140	Average Large	$118 $151	$0.17 $0.17	0.2% 0.1%
Chemical Manufacturing	114	Average Large	$26 $157	$0.21 $0.21	0.8% 0.1%
Primary Metals	44	Average Large	$21 $85	$0.09 $0.09	0.4% 0.1%
Transportation Equipment	61	Average Large	$35 $217	$0.06 $0.06	0.2% 0.03%
Note: Large facilities are establishments with greater than 100 employees.					

In general, facilities in these sectors should not incur significant overall cost burdens; however, the additional regulatory requirements could significantly affect their energy use practices by causing some facilities to switch from internal generation to external purchase, similar to the practices of most facilities in the affected industries, to avoid the regulatory burden and to obtain less expensive energy.

4.0 FLUIDIZED BED COMBUSTION WASTES

As discussed earlier, FFC waste generation is divided between two large industrial categories: the electric utility/independent power market and general industries and institutions that operate boilers using fossil fuels. Both industrial categories produce fluidized bed combustion (FBC) waste. This section provides findings of an analysis of cost and economic impacts associated with alternative disposal and management practices for mitigating human health risks from FBC waste.

4.1 DATA SOURCES

The data sources fall into two general groups: data sources for estimating costs and data sources for profiling the industry and assessing economic impacts. The data sources for estimating costs include those used to profile and develop the use of alternative management practices, data sources on waste quantities and characteristics, and data sources for unit cost estimates or cost estimating models. Major sources follow:

- The Council of Industrial Boiler Owners (CIBO) FBC Survey (CIBO, 1997)
- R.S. Means, *Environmental Remediation Cost Data* (R.S. Means, 1998a and 1998b)
- R.S. Means, *Site Work and Landscape Cost Data* (R.S. Means, 1997).

The data sources for profiling the industry and assessing economic impacts are trade association reports, general industry studies, and industry data series and reports from government sources such as the Department of Energy and the Department of Commerce. Major sources follow:

- Department of Energy, Energy Information Administration (EIA, 1995a, 1995b, 1995c, 1995d, 1995e, 1996a, 1996b, 1996c, 1996d, 1996e, 1997a, 1997b, 1997c, and 1997d)

- Department of Commerce, Bureau of the Census (DOC, 1992, 1994, 1995a, 1995b, and 1995c)

- Public Utilities Reports, Inc. (Morin, 1994; PUR, 1994).

4.2 DESIGN, OPERATION, AND COST-ESTIMATING ASSUMPTIONS

Costs are estimated for baseline (current) and alternative (compliance) risk mitigation management practices for FBC waste. The risk mitigation management practices discussed in this section reflect the range of management practices that are currently employed and the alternative management practices that the Agency believes can be employed to mitigate human health risks. The following paragraphs reflect the critical design, operating, and cost assumptions used in developing these cost estimates.

4.2.1 Waste Management Unit Size Assumptions

Baseline and compliance cost estimates were developed using unit cost data from engineering cost literature and vendor quotation for three different landfill sizes representing the range of potential FBC ash management unit capacities. Table 4-1 presents the design parameters assumed for the three different management unit sizes.

4.2.2 Population and Waste Generation Assumptions

Capital, operating, closure, and post-closure cost estimates for each design were developed, discounted into 1998 dollars, and annualized over a 40-year operating life (based on industry unit operation data) assuming a 7-percent real discount rate (based on OMB guidance). The three annualized cost estimates were curve-fitted using regression analysis into a single cost equation. Annualized costs then were estimated as a function of FBC waste generation rate on a plant-specific basis. Total industry costs were derived by summing the plant-specific cost estimates derived for the 84 FBC facilities identified in the CIBO survey of FBC operators.

Total annual FBC waste generated is estimated to be approximately 7.7-million tons. Based on CIBO information, waste generation and management/beneficial use practice data are not available for 43 of 84 potential FBC waste generators. The only information available for most of these 43 facilities is power production capacity. The power production capacity (MWe) is known for 61 of the 84 facilities. For the facilities with both known power production capacity and waste generation (tons), a regression equation was calculated that predicts ash generation as a function of power production capacity. The regression equation below was used to estimate waste generation quantities for the remaining facilities with unknown ash generation, but known capacities:

$$\text{Tons of FBC waste} = 425.7 \times (\text{MW capacity})^{1.2437}.$$

For FBC plants, the CIBO survey provided general waste management practices for approximately 75 percent of the byproduct/waste quantities. Approximately 61 percent of the total ash generated is used in

Table 4-1. Design Parameters Assumed for Small, Medium, and Large FBC Waste Landfills

Parameter		FBC Waste Landfill
Sizes	small	5,000
(tons/year)	medium	50,000[a]
	large	500,000
Depth		Pile Design
(feet)	small	1.0
	medium	1.0
	large	3.0
		Combination Fill Design
	small	17.1
	medium	51.8
	large	75.1
	reported range[b]	17.1 – 75.1
	central tendency[b]	51.8
	high end[b]	75.1
Height		Pile Design
(feet)	small	25.0
	medium	25.0
	large	84.9
		Combination Fill Design
	small	21.4
	medium	20.3
	large	74.6
Area		Pile Design
(acres)	small	7.3
	medium	106.6
	large	207.2
		Combination Fill Design
	small	4.6
	medium	24.5
	large	111.8
	reported range[b]	17 – 96
	central tendency[b]	38
	high end[b]	77

[a] Median FBC ash quantity based on reported data from and calculated data derived from CIBO, 1997
[b] CIBO, 1997

mining applications, approximately 10 percent is disposed in a synthetic/composite-lined landfill, approximately 17 percent in an unlined monofill and unknown landfill types, approximately 7 percent is used for other beneficial purposes, and the remaining 9 percent is disposed in clay-lined surface impoundments. Costs are assigned to quantities disposed in non synthetic-lined/composite lined landfill and impoundment units. In the cost estimate, impoundment quantities are treated as landfilled quantities. Other management practices and beneficial uses are assumed to be continued. The total quantity of FBC ash affected by the alternative management practices is 2.1-million tons. If mining application and agricultural application are not an acceptable practice, the total affected quantity is approximately 6.9-million tons.

For the baseline cost estimate, the Agency assumes there is one liner design for FBC ash landfills—unlined. Facilities that report having synthetic and composite liners are assigned a zero incremental compliance cost. The specific landfill capital and operation and maintenance components included in the cost estimates are identified in Table 4-2. In terms of spatial arrangement, cost estimates were developed for both combination fill (below and above ground) and pile design (above-ground) landfills. Under the alternative management scenario, the Agency assumes that generators who dispose FBC ash will construct composite-lined landfills onsite or transport them offsite to a commercial Subtitle D landfill. The most economical method is assigned to each plant depending upon its annual FBC ash generation rate.

4.3 ANNUALIZED BASELINE, COMPLIANCE, AND INCREMENTAL COSTS

EPA's estimate of the annual incremental before-tax compliance costs for FBC waste is $32.3 million per year for 2.1-million tons ($15.38/ton). If mining application and use as an agricultural amendment are subject to a ban, and quantities of FBC waste currently used in these applications are subject to alternative management, total incremental compliance costs are estimated to be $84.7 million per year for 6.9-million tons ($12.27/ton). Table 4-3 summarizes these estimates.

4.4 IMPACTS AS A FUNCTION OF SIZE

This section provides estimates of potential economic impacts on facilities, businesses, and industry of alternative management practices. The analysis here *excludes* costs for quantities currently used in mining and agriculture. Therefore, the estimated waste quantities affected include 2.1-million tons of FBC waste. A wide range of facilities and entities will be affected. FBC wastes are generated by about 84 facilities across the United States with most, about 42, being operated/owned by entities in the electric service industry (i.e., independent power producers and utilities). The remaining FBC waste generating facilities include about 7 operated by universities or colleges, about 15 operated by large businesses such as Archer Daniels Midland, General Motors Corporation, Iowa Beef Processors, Exxon, and Fort Howard Paper, and the balance, about 20, operated by various small businesses or unknown operators. Because of data constraints on ownership and financial information, the impacts on individual plants and national and regional markets can be assessed on a general basis only.

Table 4-2. Cost Components Included in Landfill Design

Component	Landfill	
	Unlined	Composite-Lined
Initial Capital Costs		
Land Purchase	Yes	Yes
Site Development	Yes	Yes
Excavation	Yes	Yes
Filter Fabric	No	Yes
1' Sand	No	Yes
2' Clay Liner	No	Yes
Synthetic (HDPE) Liner	No	Yes
Leachate Collection	No	Yes
Ground-Water Wells	No	Yes
Indirect Capital Costs	Yes	Yes
Recurring Capital Costs (5 years)		
Heavy Equipment (dump truck, bulldozer, sheepsfoot roller, water truck)	Yes	Yes
Indirect Capital Costs	Yes	Yes
Annual Operation and Maintenance Costs		
Heavy Equipment Operation	Yes	Yes
Environmental Monitoring	No	Yes
Leachate Collection and Treatment	No	Yes
Closure Costs		
6" Topsoil and Vegetation	Yes	Yes
1.5' Soil	Yes	No
Filter Fabric	No	Yes
1.5' Sand	No	Yes
2' Clay	No	Yes
Synthetic (HDPE) Liner	No	Yes
Added Fill to Achieve Slope	--	--
Cover Drainage System	No	Yes
Indirect Closure Costs	Yes	Yes
Annual Post-Closure Costs		
Environmental Monitoring	No	Yes
Landscape Maintenance	Yes	Yes
Slope Maintenance	Yes	Yes
Inspection	Yes	Yes
Administration	Yes	Yes

-- = not applicable

Reflecting general differences between industry categories and the availability of data, plant-level impacts will be analyzed using different approaches for the electric power segment and for the more broad-based and lower-waste generating industrial/institutional FBC facilities.

Table 4-3. FBC Facility Risk Mitigation Cost Estimates for FBC Waste (1998 $, 1993 tons))

Number of Facilities	Quantity (million tons)	Baseline Cost (unlined landfill, million $/yr)	Compliance Cost (composite-lined landfill, million $/yr)	Incremental
84	2.118	$30.9 ($14.71/ton)	$63.3 ($30.1/ton)	$32.4 ($15.43/ton)
Including Mining Applications and Agricultural Uses				
84	6.9	$89.1 ($12.91/ton)	$173.8 ($25.19/ton)	$84.7 ($12.28/ton)

4.4.1 Electric Power Sector

The electric power sector is characterized by rather homogeneous operations for which fossil fuel, when used, is the single largest production input. To indicate the general magnitude of impacts on such plants, general model or representative financial pro forma statements have been developed that will indicate the general level of economic conditions and impacts common types of plants and plant operators should experience.

In this analysis, only the general nature of impacts are assessed relative to normal/average management and financial conditions for fossil fuel burning plants. The partial budgeting analysis, using model plants, is limited to ratio analysis of general operating conditions (i.e., effect on costs and net income). Pro forma operating and financial profiles (Table 4-4) present both the baseline economic parameters for representative plants, as well as compliance costs. The economic parameters are limited to income statement measures to assess the general effect on an operation's viability. Capital budget or balance sheet impacts are not considered. The cost options evaluated in this analysis include constructing composite-lined landfills onsite or transporting FBC waste to an offsite commercial landfill.

The analysis indicates the management of FBC ash under expected management options should not cause significant impacts on the financial viability of independent power producer FBC facilities. This appears true even for plants that are switching from the worst case unlined landfill baseline management method to a composite-lined landfill. For example, a large FBC independent power plant with 100 MW of generating capacity and generating 540-million kWh per year is estimated to be able to mitigate risks from FBC ash for about $520,000 per year or about $13/ton. Based on typical annual revenues and cost, compliance costs would increase overall costs by 1.4 percent of revenues. Without any price

Table 4-4. Pro Forma Financial Analysis of Economic Impacts for FBC Wastes

	Units	Large FBC Independent Power Producer			Medium FBC Independent Power Producer			Small FBC Independent Power Producer		
		No.	Percent	Notes	No.	Percent	Notes	No.	Percent	Notes
FACILITY CHARACTERISTICS										
Facility Generating Capacity	MW	100		a	50		a	30		a
Fuel Consumption: Coal	1,000 s.t.	470		b	235		b	141		b
Sales of Electricity	Mil. kwh	540.5		b	270.25		b	162.15		b
Price of Electricity	$/kwh	0.07		c	0.07		c	0.07		c
Revenues from Electricity	$1,000	37,840	100.0%	d	189,000	100.0%	d	11,400	100.0%	d
COSTS										
Energy Costs	$1,000	18,920	50.0%	e	9,460	50.0%	e	5,680	50.0%	e
Operating Expenses	$1,000	11,730	31.0%	e	6,240	33.0%	e	3,860	34.0%	e
Interest Expenses	$1,000	3,410	9.0%	e	1,700	9.0%	e	1,020	9.0%	e
Total Baseline Costs	$1,000	34,060	90.0%	e	17,400	92.0%	e	10,560	93.0%	e
NET INCOME: Baseline Before Tax	$1,000	3,780	***10.0%***	e	1,510	***8.0%***	e	790	***7.0%***	e
INCREMENTAL COST	$1,000	520	1.4%	d	280	1.5%	d	190	1.7%	d
NET INCOME: Post-Compliance	$1,000	3,260	***8.6%***		1,230	6.5%		600	***5.3%***	
COMPLIANCE ASSUMPTIONS										
Waste Generated: Coal Ash	tons	40,000		f	20,000		f	12,000		f
Compliance Option		Onsite/Offsite Lined LF			Onsite/Offsite Lined LF			Onsite/Offsite Lined LF		
Unit Cost of Compliance	$/ton	13			14			16		

a. Based on general MW capacity distribution of SIC 49xx from FBC generators
b. EIA, 1997e. In 1996, 53,199,000 short tons of coal were consumed by non-utilities for 11,300 MW of capacity or about 4,700 short tons per MW capacity, which generated 61.38-billion kWh of electricity (1.15 kWh/short tons)
c. Assumed same price as for coal utilities, but DOE does not report revenue or price from non-utility generation
d. Computed. For revenue, an equivalent value assumed for any electricity generation used internally
e. Estimated assuming the same general cost structure as utilities but with income levels similar to public utilities (i.e., not investor-owned)
f. Based on a sample of 20 FBC non-utility facilities generating a combined total of 807,749 tons of FBC waste
g. Average for non-utility FBC units is $13.80/ton ($15.2 million/1.1 million tons) and adjusted to economies of size

adjustments, net income before taxes for a typical FBC facility would be reduced from about 10 percent to 8.6 percent and remain at more than $3.3 million per year (Table 4-4).

Financial impacts on a medium-sized FBC independent power plant suggest it should also remain financially viable. Costs would increase by about 1.5 percent of revenues, with profitability (before tax) at 6.5 percent of revenue and net income levels after compliance of more than $1.2 million per year. Annual incremental compliance costs are estimated at $14 per ton of FBC ash, or about $280,000 per year (Table 4-4). Small FBC independent power plants would incur similar impacts to medium-sized facilities.

The plant-level findings presented above are subject to limitations. The primary limitation is they do not reflect the great variation that exists between plants in terms of efficiency, electricity pricing, management quality, and age and level of generating technology. While the models do provide a reasonable representation of the norm, substantial variation can occur both above and below the figures shown. Also, this analysis is restricted to operations exhibiting positive returns in the baseline; i.e., plants that are financially viable in the baseline. Marginal operations can appear to have significant financial impacts, but these should be attributed to poor management or inefficient operations and not alternative management.

4.4.2 Industrial/Institutional Sectors

As for conventional non-utility combustors, industrial and institutional FBC facilities include a wide variety of facilities that generate electricity or energy for primarily internal use. The vast majority of firms in these sectors, however, do not operate FBC units or burn coal at all. Because of the smaller number of affected FBC facilities, FBC facilities represent an even smaller share of the corresponding industry sectors than do conventional non-utility combustors. As for conventional non-utilities, fossil fuel use and costs are a relatively small part of production inputs and costs. Therefore, the conclusions presented in the paragraph above and in Section 3.4 generally also are applicable to industrial and institutional FBC facilities.

5.0 OIL COMBUSTION WASTES

As discussed above, FFC generation is divided between two large industrial categories: the electric utility/independent power market and general industries and institutions that operate boilers using fossil fuels. The electric utility industry is the primary generator of oil combustion wastes (OCWs). Because of the small amount of waste generated and the limited data available, OCWs from non-utility combusters are not included in this analysis. This section provides findings of an analysis of cost and economic impacts associated with alternative disposal and management practices for mitigating human health risks from OCWs.

5.1 DATA SOURCES

The data sources fall into two general groups: data sources for estimating costs and data sources for profiling the industry and assessing economic impacts. The sources for estimating costs include those used to profile and develop the use of alternative management practices, sources on waste quantities and characteristics, and sources for unit cost estimates or cost estimating models. Major sources follow:

- EPRI Oil Combustion Report (EPRI, 1998)
- Edison Electric Institute Power Statistics Database (EEI, 1994)
- R.S. Means, *Environmental Remediation Cost Data* (R.S. Means, 1998a and 1998b)
- R.S. Means, *Site Work and Landscape Cost Data* (R.S. Means, 1997).

The data sources for profiling the industry and assessing economic impacts are trade association reports, general industry studies, and industry data series and reports from government sources such as the Department of Energy and the Department of Commerce. Major sources follow:

- Department of Energy, Energy Information Administration (EIA, 1995a, 1995b, 1995c, 1995d, 1995e, 1996a, 1996b, 1996c, 1996d, 1996e, 1997a, 1997b, 1997c, and 1997d)

- Department of Commerce, Bureau of the Census (DOC, 1992, 1994, 1995a, 1995b, and 1995c)

- Public Utilities Reports, Inc. (Morin, 1994; PUR, 1994).

5.2 DESIGN, OPERATION, AND COST-ESTIMATING ASSUMPTIONS

Costs are estimated for baseline (current) and alternative (compliance) risk mitigation management practices for OCW generated by oil-fired utility plants. The risk mitigation management practices discussed in this section reflect the range of management practices that are currently employed and the alternative management practices that the Agency believes can be employed to mitigate human health risks. The following paragraphs reflect the critical design, operating, and cost assumptions used in developing these cost estimates.

5.2.1 Waste Management Unit Size Assumptions

Baseline and compliance cost estimates were developed using unit cost data from engineering cost literature and vendor quotation for three different impoundment sizes representing the range of potential OCW management unit capacities. Table 5-1 presents the design parameters assumed for the three different management unit sizes.

Table 5-1. Design Parameters Assumed for Small, Medium, and Large OCW Solids Setting Basins (SSBs)

Parameter		OCW SSB
Sizes (dry tons/year)	small	36
	medium	172
	large	923
Depth (feet)	small	8.0
	medium	11.0
	large	12.0
Area (acres)	small	0.3
	medium	1.0
	large	2.5
	reported range*	0.1 – 12.8
	central tendency	1.0
* EPRI, 1998		

5.2.2 Population and Waste Generation Assumptions

Capital, operating, closure, and post-closure cost estimates for each design were developed, discounted into 1998 dollars, and annualized over a 40-year operating life (based on industry unit operation data) assuming a 7-percent real discount rate (based on OMB guidance). The three annualized cost estimates were curve-fitted using regression analysis into a single cost equation. Annualized costs then were estimated as a function of OCW generation rate on a plant-specific basis. Total industry costs were derived by summing the plant-specific cost estimates derived for the 89 identified oil-fired plants identified in the EEI database (EEI, 1994) with electrical generating capacities of at least 10 MW.

Total annual OCW generation is estimated to range from 19,000 to 110,000 dry tons, with an expected value of 28,000 dry tons. EPRI conducted studies on a sample of oil plants. At these plants, between 180 dry tons/million barrels of oil and 1,050 dry tons/million barrels of oil, with an average of 270 dry tons/million barrels of oil, of OCW are generated. Using these generation rates as a guideline, three oil ash generation rate scenarios (low, medium, and high) are estimated. EPRI estimates that 90 percent of the oil ash generated is fly ash and 10 percent is bottom ash and washwater solids (EPRI, 1998).

5.2.3 Waste Management Unit Design Assumptions

For the baseline cost estimate, the Agency assumed a concrete basin design for oil ash SSBs (impoundments). EPRI's sample of oil-fired utilities indicate that 15 out of 16 plants (94 percent) have SSBs and 6 out of 15 plants (40 percent) with SSBs have single-synthetic liners. Therefore, 7 out of 16 plants (44 percent) will not incur compliance costs. The specific impoundment capital and operation and maintenance components included in the cost estimates are identified in Table 5-2. For compliance with new regulations, the Agency assumed that generators of oil ash will construct composite-lined SSBs in the same location as the current units.

Excavation and construction of the concrete basin, concrete sludge drying basin, and discharge structure costs are included in the compliance cost to net out costs that are not incremental. The true incremental cost includes only a fractional increase in excavation for sloping of the composite-lined SSB and demolition of the concrete basin.

5.3 ANNUALIZED BASELINE, COMPLIANCE, AND INCREMENTAL COSTS

A summary of the annual incremental before-tax compliance costs for OCW is presented in Table 5-3. Incremental compliance costs for oil ash are estimated to be $1.7 million per year for 15,680 dry tons ($106.33/dry ton). The potential range of annual incremental compliance cost is from $1.0 million to $3.5 million, accounting for uncertainty in estimated quantities and unit costs.

Table 5-2. Cost Components Included in OCW SSB Designs

Component	Impoundment	
	Unlined	Composite-Lined
Initial Capital Costs		
Site Development (access road, drainage ditch)	Yes	Yes
Excavation	Yes	Yes
Concrete Basin	Yes	Yes
Concrete Sludge Drying Basin	Yes	Yes
Discharge Structure	Yes	Yes
Concrete Basin Demolition	No	Yes
Filter Fabric	No	Yes
1' Sand	No	Yes
2' Clay Liner	No	Yes
Synthetic (HDPE) Liner	No	Yes
Leachate Collection	No	Yes
Synthetic Liner for Sludge Drying Basin	No	Yes
Ground-Water Wells	No	Yes
Indirect Capital Costs	Yes	Yes
Annual Operation and Maintenance Costs		
Dredging	Yes	Yes
Ash Dewatering	Yes	Yes
Operating and Maintenance Labor	Yes	Yes
Electricity	Yes	Yes
Offsite Subtitle D Landfill Ash Disposal	Yes	Yes
Environmental Monitoring	No	Yes
Leachate Collection and Treatment	No	Yes
Closure Costs		
Pressure Wash Sludge Drying Basin	Yes	Yes
Final Ash Dredging, Dewatering, and Subtitle D Disposal	No	Yes
Backfill of Concrete Basin	Yes	Yes
6" Topsoil and Vegetation	Yes	Yes
1.5' Soil	Yes	Yes
Leachate Sampling	No	Yes
Indirect Closure Costs	Yes	Yes

5.4 IMPACTS AS A FUNCTION OF PLANT SIZE

This section provides estimates of the potential economic impacts on facilities, businesses, and industry of alternative management practices for OCW. Affected waste quantities include 28,000 tons ash (dry) from oil-fired electric utility operations owned by entities including private and investor-owned companies, small and large local governments, and the federal government. Because of data constraints on ownership and financial information, the impacts on individual plants and national and regional markets can be assessed on a general basis only.

Table 5-3. Oil-Fired Utility Risk Mitigation Cost Estimates for OCW (1998 $, 1993 tons)

	Baseline	Compliance	Incremental
Scenario	Unlined and Synthetic-Lined	Composite-Lined	SSB
Total Quantity (dry tons)	28,000	28,000	28,000
Cost (million $/yr)	$12.4	$15.4	$3.0
Current percentage with Adequate Liner or no SSB*	44%	44%	44%
Quantity with Inadequate Liners (dry tons)	15,680	15,680	15,680
Costs for Affected Quantity (million $/yr)	$6.9 ($444.25/dry ton)	$8.6 ($550.58/dry ton)	$1.7 ($106.33/dry ton)

*Includes the percentage of units currently having single-synthetic liners. Other units are unlined or concrete-lined or have no SSB.

The electric utility sector is characterized by rather homogeneous operations for which fossil fuel, when used, is the single largest production input. To indicate the general magnitude of impacts on such plants, general model or representative financial pro forma statements have been developed that indicate the general level of economic conditions and impacts common types of plants and plant operators should experience.

In this analysis, the general nature of impacts only are assessed relative to normal/average management and financial conditions for fossil fuel burning plants. The partial budgeting analysis, using model plants, is limited to ratio analysis of general operating conditions (i.e., effect on costs and net income). Pro forma operating and financial profiles (Table 5-4) present both the baseline economic parameters for representative plants, as well as compliance costs. The economic parameters are limited to income statement measures to assess the general effect on an operation's viability. Capital budget or balance sheet impacts are not considered at this time. The cost options evaluated in this analysis include constructing composite-lined SSBs for oil-fired plants.

The preliminary impacts analysis indicates the management of OCW under expected management options should not cause significant impacts on the financial viability of oil-fired plants. The impacts are higher on a unit basis, but waste generation rates per unit of output are very low for oil plants compared to coal plants. For a large publicly owned oil-fired plant generating about 1.2-billion kWh per year, costs are expected to increase only $43,000 annually to manage oil ash waste as hazardous. This would increase costs by about 0.1 percent of annual revenue and thus reduce net income from 9.0 percent of

Table 5-4. Pro Forma Financial Analysis of Economic Impacts for Utility OCW

		LARGE OIL PLANT Publicly Owned Utility			MID-SIZED OIL PLANT Publicly Owned Utility			SMALL OIL PLANT Publicly Owned Utility		
	Units	No.	Percent	Notes	No.	Percent	Notes	No.	Percent	Notes
Plant Generating Capacity	MW	923		c	231		c	38		c
Fuel Consumption: Oil	1,000 bbl	2,000		c	500		c	83		c
Sales of Electricity	Mil. kwh	1,200			300			50		
Price of Electricity	$/kwh	0.06		a	0.06		a	0.06		a
Revenues from Electricity	$1,000	72,000	100.0%	b	18,000	100.0%	b	3,000	100.0%	b
COSTS										
Energy Costs	$1,000	43,200	60.0%	d	10,800	60.0%	d	1,800	60.0%	d
Operating Expenses	$1,000	18,000	25.0%	b	4,500	25.0%	b	810	27.0%	b
Interest Expenses	$1,000	4,320	6.0%	d	1,080	6.0%	d	180	6.0%	d
Total Baseline Costs	$1,000	65,520	91.0%	b	16,380	91.0%	b	2,790	93.0%	b
NET INCOME: Baseline Before Tax	$1,000	6,480	***9.0%***	d	1,620	***9.0%***	d	210	***7.0%***	d
INCREMENTAL COST	$1,000	43	0.1%		29	0.2%		12	0.4%	
NET INCOME: Post-Compliance	$1,000	6,437	***8.9%***		1,591	***8.8%***		198	***6.6%***	
COMPLIANCE ASSUMPTIONS										
Waste Generated	dry tons	540		e	135		e	22		e
Compliance Option		Lined SSB			Lined SSB			Lined SSB		
Unit Cost of Compliance	$/dry ton	80.10			213.42			533.81		

a. EIA, 1996f
b. Computed based on other assumptions
c. EIA, 1995a
d. Ratio analysis of sample utilities from EIA, 1997a. Conversions: fuel oil unit productivity = 1.301506-million kWh per MW capacity; fuel oil efficiency = 602.649-million kWh per million barrels of fuel oil.
e. EPRI, 1998

revenue to 8.9 percent of revenue. Net income dollars would thus be reduced from $6.48 million to $6.43 million per year (Table 5-4).

Smaller oil-fired plants would be affected more significantly, but still not incur significant financial impacts under normal financial conditions. Per-ton waste management costs will be in the range of $200 to $500 per ton, but total compliance costs, as a percent of revenue, would climb about 0.2 to 0.4 percent only. Annual net income for plants generating from 50- to 300-million kWh per year is estimated to decline about $12,000 to $30,000 per year, but still show significant positive returns and, thus, remain financially viable. If such plants could increase prices to offset waste management costs, they would only need to increase from the representative baseline price of 6 cents per kWh to 6.02 cents per kWh.

Based on a cross-section of representative oil-fired plants, therefore, impacts at the plant level for mitigating risks from OCW are expected to be insignificant in terms of financially threatening normal operations. Generally, both investor and publicly owned plants exhibit net returns of 7 to 9 percent of revenue. Costs for any such operations on average are not expected to increase more than 0.4 percent of revenues, thus allowing net income to remain positive.

The plant-level findings presented above are subject to limitations. The primary limitation is that they do not reflect the great variation that exists between plants in terms of efficiency, electricity pricing, management quality, and age and level of generating technology. While the models do provide a reasonable representation of the norm, substantial variation can occur both above and below the figures shown. Also, this analysis is restricted to operations exhibiting positive returns in the baseline; i.e., plants that are financially viable in the baseline. Marginal operations can appear to have significant financial impacts, but these should be attributed to poor management or inefficient operations and not alternative management.

6.0 INDUSTRY IMPACTS AND CONCLUSIONS

In general, national and regional impacts are addressed with a combination of qualitative analysis and basic quantitative analysis. Use of econometric models is judged to be neither feasible nor justifiable given the complex and quickly changing nature of the electricity market and industry and the highly diverse nature and complex structure of other industrial and institutional sectors affected.

Alternative management for FFC wastes would affect essentially all elements of the economy and society. The extent of such effects will largely be determined by the eventual incidence and magnitude of compliance costs. The general results of this analysis show that the direct effects will be confined to primarily the supply and price of electricity with some much lesser direct effects for other fossil fuel consuming industries such as food processors, pulp and paper mills, and chemical manufacturers discussed later in this report. The overall impact of proposed regulations to these industries relative to compliance costs is a key indicator of the extent industry markets and operations will change. The annual value of some of these key markets follows:

Electricity	$212 billion (1996)
Pulp and Paper Mills (SIC 26)	$52 billion (1995)
Chemicals (SIC 28)	$362 billion (1995)
Food Processing (SIC 20)	$448 billion (1995)
Primary Metals (SIC 33)	$180 billion (1995)
Transportation Equipment (SIC 37)	$463 billion (1995)

In comparison, overall incremental costs of compliance for all waste types are estimated to be about $1.0 billion. While these costs are significant, they will be incurred by industries with market values of well over $1.7 trillion; consequently, compliance costs on average will be less than 0.06 percent of overall industry sales.

The most significant impacts are to the electric utility industry, which will incur about $0.9 billion in incremental annualized compliance costs. This would represent 0.4 percent of the industry's value of shipments and is highly concentrated in the coal-fired utility component, which accounts for about 56 percent of all electricity generated in the United States. This impact likely will be taken into consideration, along with several other factors, to assess how soon to close down marginal coal plants and what type of new plants to build. This implies that a possible effect of the proposed regulations is a shift to alternative energy sources. Table 6-1 provides a summary of the national, industry, and plant-level impacts resulting from this regulatory determination. The sections below provide additional discussion of impacts on the utility and non-utility sectors.

6.1 ELECTRIC POWER INDUSTRY

The electric power generating industry, including fossil fuel, hydroelectric, nuclear, and other fuel sources, was a $212-billion-per-year industry in 1996. Other economic characteristics of the electric utility industry follow:

- An average price to consumers of 6.86 cents per kWh in 1996, which can vary from less than 3 cents per kWh for industrial customers of a federal utility to more than 15 cents per kWh for residential customers of a northeastern investor-owned utility

- Annual electricity consumption of 3,120 billion kWh (1997) or 11,860 kWh per capita

- 3,200 entities selling electricity with industry ownership, including the following:

  - 243 investor-owned utilities (7.6 percent of all utilities) producing 76 percent of U.S. electricity sales (2,343-billion kWh and $167 billion or $687 million per entity)

  - 2,014 smaller public utilities (mainly municipalities and other local government entities and 63 percent of all utilities) producing only 14.5 percent of the electricity sales (451-billion kWh and $27 billion or $13 million per entity)

  - 932 cooperatives (29 percent of all utilities) producing 8 percent of industry sales (241-billion kWh and $17 billion or $18 million per entity)

  - 10 federal utilities (0.3 percent of all utilities) accounting for 0.6 percent of electricity sales (50-billion kWh and $1.3 billion or $130 million per federal utility)

- Electricity production in 1997 by major fuel types for electric utilities includes about 1,789-billion kWh from coal (898-million short tons), about 78-billion kWh from petroleum (128-million barrels), about 283-billion kWh from gas (2,962 billion cubic feet), about 630-billion kWh from nuclear, and about 340-billion kWh from hydroelectric

- Trends in greater use of coal (774-million short tons in 1990 versus 898-million short tons in 1997) and less use of petroleum (196-million barrels in 1990 versus 128-million barrels in 1997).

From an economic impact perspective, not only is petroleum use declining for electricity generation, but it also is regionally more concentrated than is the more ubiquitous coal generation. For example, five states (Florida, 39.4-million barrels; Massachusetts, 17.4-million barrels; Connecticut, 14.1-million barrels; New York, 13.8-million barrels; and Hawaii, 10.8-million barrels) accounted for 75 percent of the petroleum used for electricity generation in the United States in 1997.

Even more important from an economic perspective, the U.S. electric power industry is entering an era of major restructuring. It is restructuring from a mix of regionally or state regulated monopolistic markets to a more open national market. The eventual results of this transition are uncharted and uncertain. This was stimulated to a great extent by high regional differences in electricity prices being experienced by industrial users. These industrial users have influenced states and the Federal Energy Regulatory Commission to encourage competition between utilities themselves and newer, less-regulated non-utilities.

This increased regional competition has had several major immediate effects on the utility markets. First, several investor-owned utilities (IOUs) have merged in anticipation of more open national competition and greater access to the market. Also, utilities, particularly IOUs, have reorganized operations, restructured fuel contracts, and reduced staff to make greater efforts at cutting costs. The DOE estimates IOUs' real operation and maintenance costs (in 1995 dollars) have declined from about 4.5 cents per kWh in 1986 to 3.5 cents in 1995. Finally, new competition or operations are entering the market and replacing IOUs' and public utilities' sales or operations. Unregulated independent power generators are building plants and buying electricity on the open market from other generators for sale to traditional electricity consumers. Some IOUs are being required to turn over operation of their transmission systems to independent system operators to ensure open access to markets by other generators.

This restructuring complicates assessing the impacts of alternative management of FFC wastes; however, the aggregate cost of compliance estimates should still serve as a good proxy for the overall potential shift in the supply of electricity, which will be used to make general estimates of price effects. The distributional nature of this price effect cannot be documented except to identify which plants will have the greatest need to pass through costs in the form of higher prices, and which will be restricted by competition from unaffected plants (i.e., hydro and nuclear). Ultimately, IOUs representing about only 8 percent of utility operators, will be the major determinants of price effects as they control about 80 percent of electric energy sales (as well as the majority of large coal-fired plants). IOUs also are merging and consolidating operations rapidly, and will be the primary players in a more open and national electricity market.

6.2 INDUSTRIAL/INSTITUTIONAL SECTORS

The overall market and, by inference, the welfare effects of FFC waste management requirements on general industrial and institutional markets, can be addressed by assessing the general implications for market supply of selected industries. For example, the food processing sector may incur direct impacts from increased FFC waste management costs of $9.7 million per year. This sector, however, was a $448-billion-per-year industry in 1995. Thus, FFC compliance costs should represent less the 0.005 percent of overall market value and not cause significant effects. Moreover, only about 1 out of every 150 facilities should be directly affected. Similar results occur for other industry comparisons, as shown in Table 6-1.

Table 6-1. Summary of Impacts

INDUSTRY IMPACTS				PLANT-LEVEL IMPACTS				
Sector	**Sales ($billion/yr)**	**Incremental Cost ($billion/yr)**	**Percent of Sales**	**Size**	**Number of Plants (Percent)**	**Sales ($million /yr)**	**Compliance Cost ($million/yr)**	**Percent of Sales**
Coal-Fired Utilities	$212	$0.9	0.4%	Large Medium Small	148 (42%) 61 (17%) 144 (41%)	$426 $142 $60	$6.2–7.7 $2.2–2.8 $1.3–1.6	1.5–1.8% 1.6–1.9% 2.1–2.6%
Oil-Fired Utilities	$4.3	$0.002	0.05%	Large Medium Small	43 (35%) 15 (17%) 31 (48%)	$72 $18 $3	$0.04 $0.03 $0.01	0.1% 0.2% 0.4%
FBC Independent Power Producers	$4.3	$0.015	0.3%	Average	42 (50%)	< $50	$0.36	> 0.7%
FBC Industrial/ Institutional	Not Estimated[a]	$0.017	--	--	42 (50%)	Not Estimated[a]	$0.40	--
Food Processing[c]	$448	$0.010	0.002%	Average Large[b]	98 (10%) --	$19 $81	$0.10	0.5% 0.1%
Pulp and Paper[c]	$52	$0.024	0.050%	Average Large[b]	140 (15%) --	$118 $151	$0.17	0.2% 0.1%
Chemical Manufacturing[c]	$362	$0.024	0.010%	Average Large[b]	114 (12%) --	$26 $157	$0.21	0.8% 0.1%
Primary Metals[c]	$180	$0.004	0.002%	Average Large[b]	44 (5%) --	$21 $85	$0.09	0.4% 0.1%
Transportation Equipment[c]	$463	$0.003	0.001%	Average Large[b]	61 (6%) --	$35 $217	$0.06	0.2% 0.03%
Other Industrial/ Institutional	Not Estimated[a]	$0.026	--	--	457 (48%)	Not Estimated[a]	$0.06	--
TOTAL	$1,721	$1.0	0.06%					

[a] Not estimated due to the wide variety of SIC codes represented
[b] Establishments with greater than 100 employees
[c] These five industries account for approximately 80 percent of the coal ash generated by 18 reporting industries and institutional sectors covered in EPA, 1990
-- = not applicable
Note: Individual values may not sum to total due to rounding.

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